Design of aerated high pressure reactors for enzyme catalysed reactions

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Motivation & Objective

The use of enzymes as catalyst has increased significantly in recent decades.

Applying pressure can further improve the potential of the enzymes:

- *Higher enzyme stability, activity[1], selectivity[2].*
- *Gas consuming reactions can profit from higher gas solubility.*[3]

Utilization of pressure effects through the development of:

→ *Low-shear high-pressure reactors.*

→ *Online and in situ analytical methods suitable for high pressure.*

→ *Characterization of the enzyme activity under pressure within the reactor system by the integrated measurement technology.*

Enzyme Immobilization

- Covalent binding of the enzyme to bioavailable polyamide 12 (PA 12).
- Adaptation of a method for immobilization of tyrosine at PA 12 carrier structures.
- Production through additive manufacturing.
- Use of periodic open cell structures (POCS)[4]
- Variation of the POCS geometry:
  - *Polyhedra*
  - *Star Tetrahedron*
  - *Gyroids.*

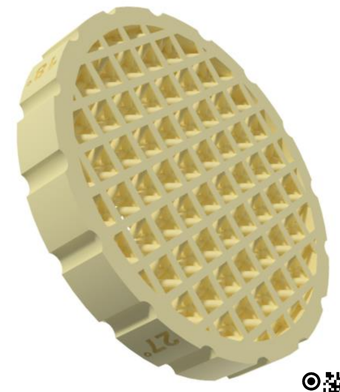

Fig. 3: *CAD model of the carrier structure.*

Laboratory Prototype

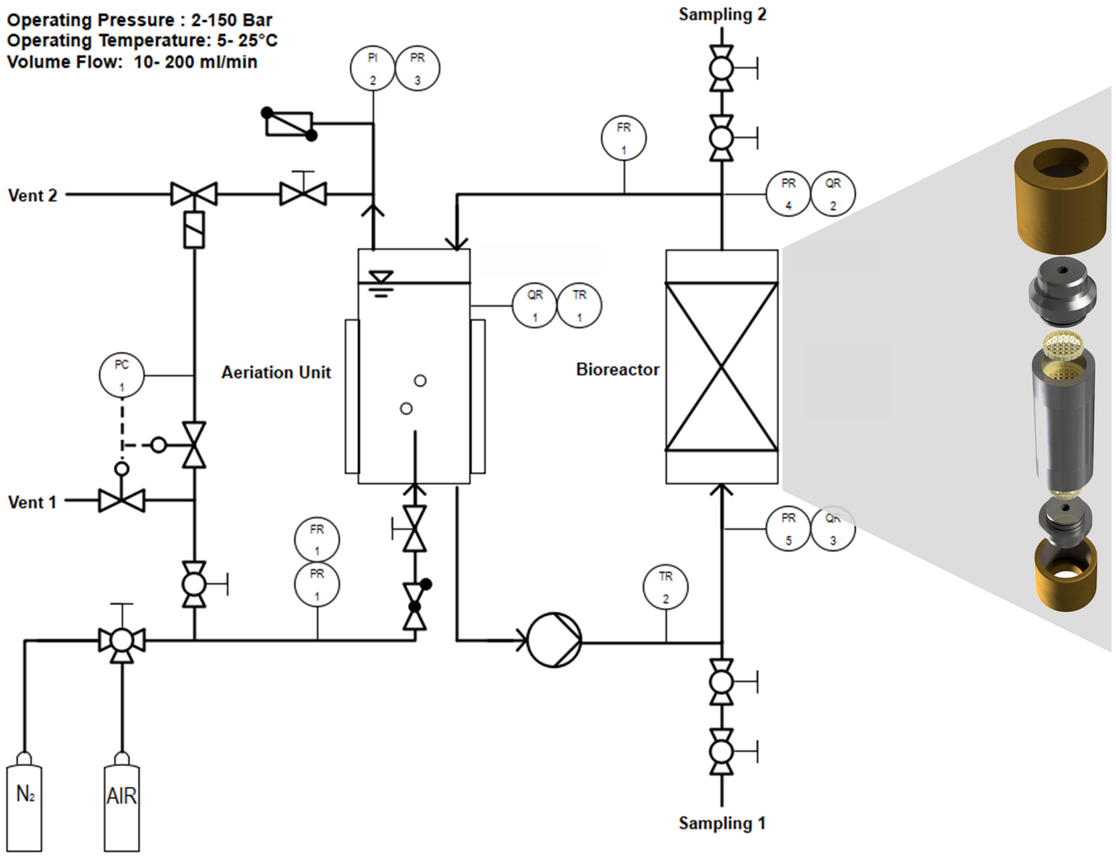

Fig. 1: *Flow diagram of the laboratory prototype.*

- Reactor setup with spatial separation of aeration and enzymes to minimize shear stress.
- Online and *in situ* monitoring of the oxygen Monitoring enzyme activity via oxygen consumption in the substrate.
- Model reaction is the oxidation of L-tyrosine to L-DOPA by tyrosinase (EC 1.14.18.1).

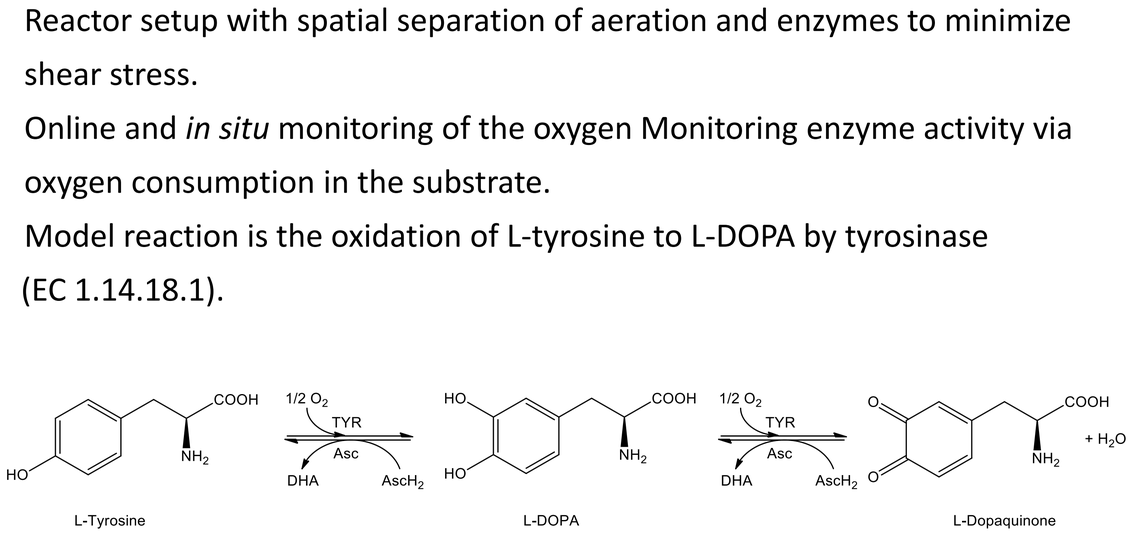

Fig. 2: *Reaction equation of the model reaction.*

- Tyrosinase is inserted into the bioreactor in immobilized state.

Results

- In the first project phase a reactor design was developed and tested:
  - Allows a bubble- and therefore foam-free aeration.
  - Allows high turnover without oxygen limitation.
  - Leads to no enzyme damage through shear stress.

➢ Oxygen depletion can be observed between the sensors at the inlet and outlet of the reactor (Fig. 4)

➢ The measured consumption is also reflected in the course of the L-tyrosine turnover.

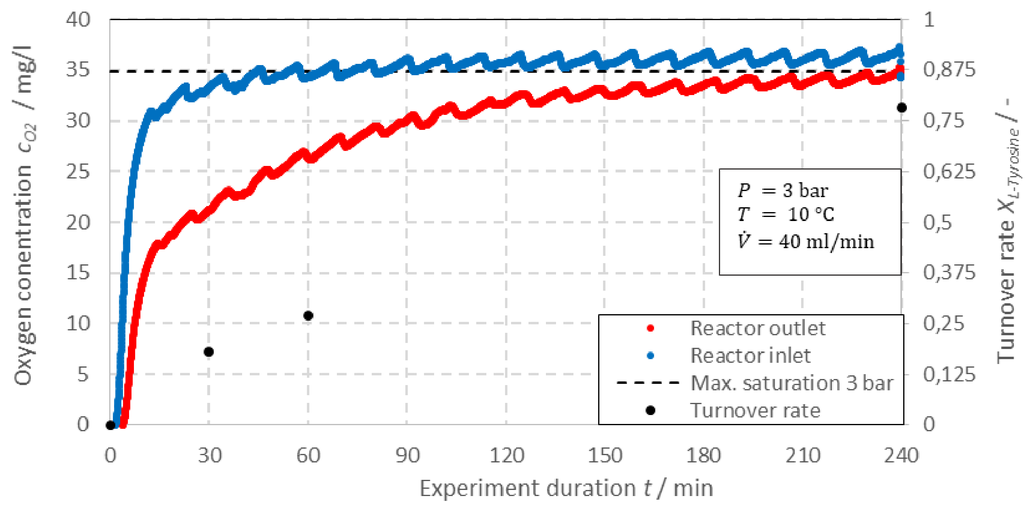

Fig. 4: *Oxygen consumption by the enzyme compared to the supplied oxygen.*

- For the immobilization of the enzymes:
  - ➢ Adapted 3D printed structures have been developed.
  - ➢ An immobilization method could be successfully established.

Future Work & Outlook

- ➢ *Deeper characterization of the prototype up to pressures of 150 bar.*
- ➢ *Scale up of the laboratory setup to pilot scale.*
- ➢ *Integration of the sensor technology into 3D printed carrier structure.*

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